fsPHENIX calorimeters

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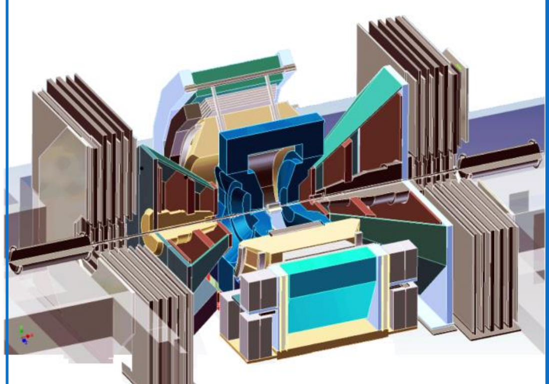
Road map

Documented: http://www.phenix.bnl.gov/plans.html

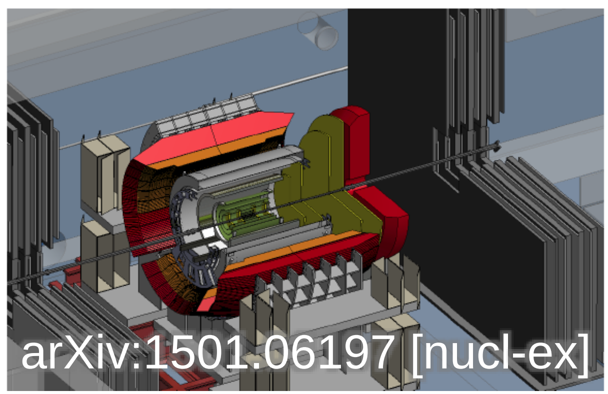
Current PHENIX

- 14y+ operation
  100+M$ investment
- Broad spectrum of physics (QGP, Hadron Physics, DM)
- 140+ published papers to date
- Last run in this form 2016



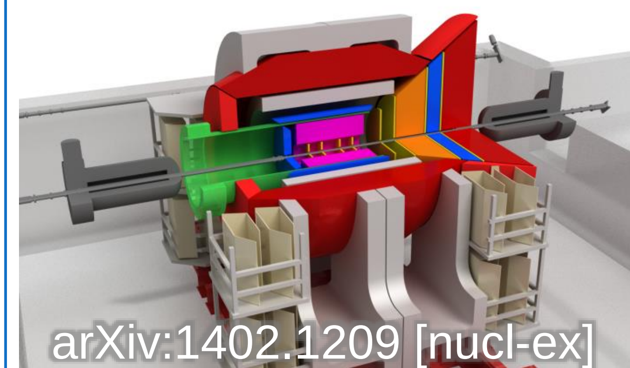
*s*PHENIX (+fsPHENIX)

- Comprehensive central upgrade base on BaBar magnet
- Rich jet and beauty quarkonia physics program
  → nature of QGP
- fsPHENIX : forward tracking, Hcal and muon ID → Spin, CNM



An EIC detector

- Path of PHENIX upgrade leads to a capable EIC detector
- Large coverage of tracking, calorimetry and PID
- Open for new collaboration/new ideas

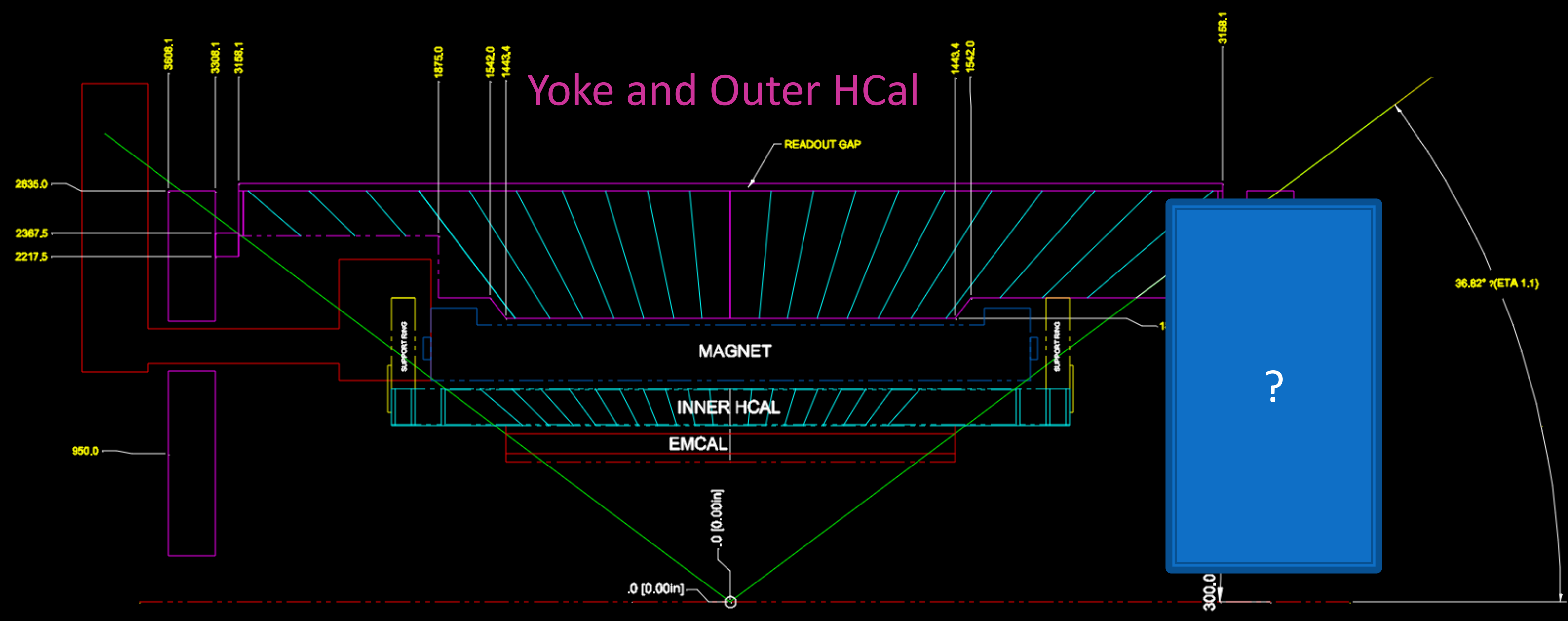


~2000 — 2017→2020 — ~2025 — Time

RHIC: A+A, spin-polarized p+p, spin-polarized p+A

EIC: e+p, e+A

From R. Ruggiero (BNL/PHENIX)



Envelope on current sPHENIX design (calorimeter only)

HCal geometry is significantly revised

Preliminary magnetic end-door design

Calorimetry overview

- This talk is to walk through consideration of forward calorimeter design and collect your feed back.
- Jet energy resolution
  - Primary serve for kinematics determination
  - Tail under control (<20%?) for unfolding
- Jet angular resolution
  - Primary serve for relative momentum determination, e.g. hadron in jet, jet-gamma correlation, jet-jet correlation
- Assist DY muon ID
  - DY muon leave ~3GeV MIP signal in HCal. Independent check with muon ID
  - Isolation around the muon track candidate
- EMCal layer open up possibility of electron-DY too
- Jets and hadron final state detection @ EIC ($-1<\eta<+4$)
  - See also next talk Vladimir Skokov

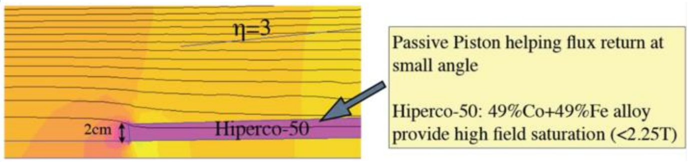
Calorimeter as part of magnet system

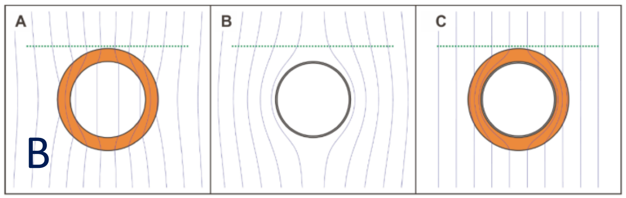
- Calorimeter system serve as forward magnetic field return
  Defines forward field geometry and tracking/PID volumne

What field shall we add in the forward?
- Brain storm in the past few years

Design Family	Example
Piston	• Passive piston (C. L. da Silva) • Active piston (J. Huang, C. L. da Silva) • Super conducting piston (Y. Goto)
Dipole	• Forward dipole (Y. Goto, A. Deshpande, et. al.) • Redirect magnetic flux of solenoid (T. Hemmick) • Use less-magnetic material for a azimuthal portion of central H-Cal (E. Kistenev)
Toroid	• Air core toroid (E. Kistenev) • Six fold toroid (J. Huang)
Other axial symmetric Field shaper	• Large field solenoidal extension (C. L. da Silva) • Pancake field pusher (T. Hemmick)

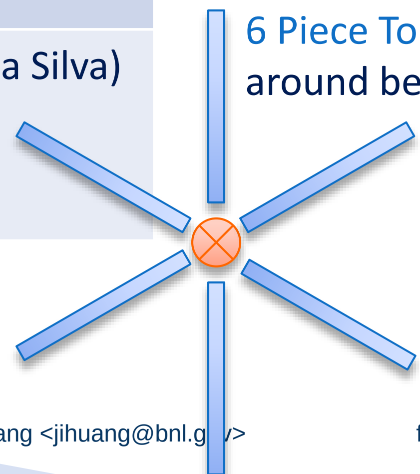
Passive piston

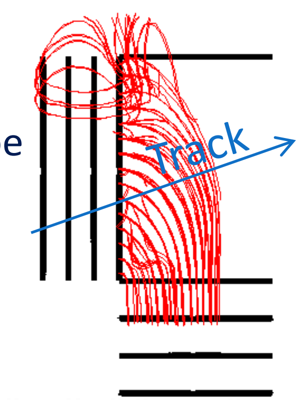




Beam line magnetic field shielding, based on superconducting pipe.

6 Piece Toroid around beam pipe



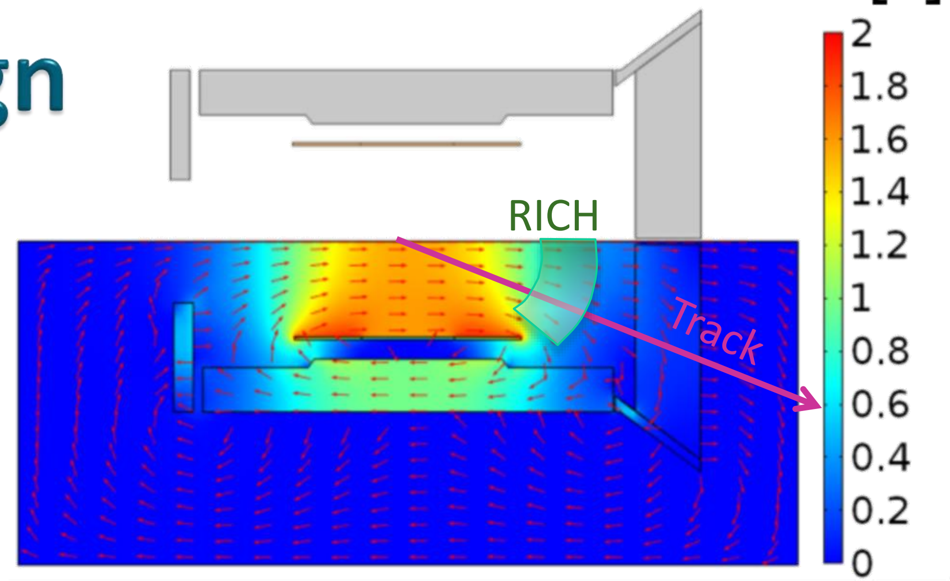


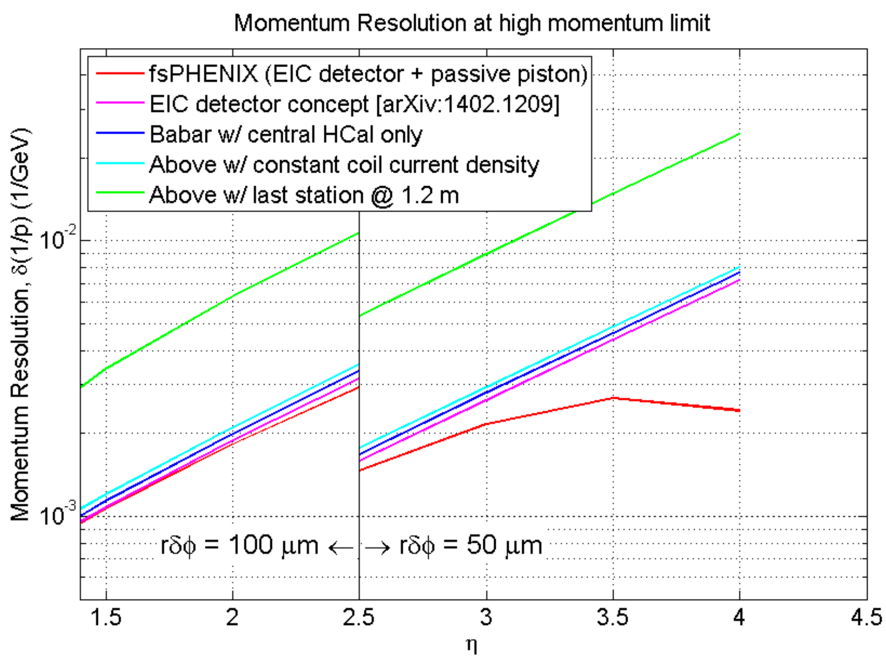
Pancake field pusher

Forward field design

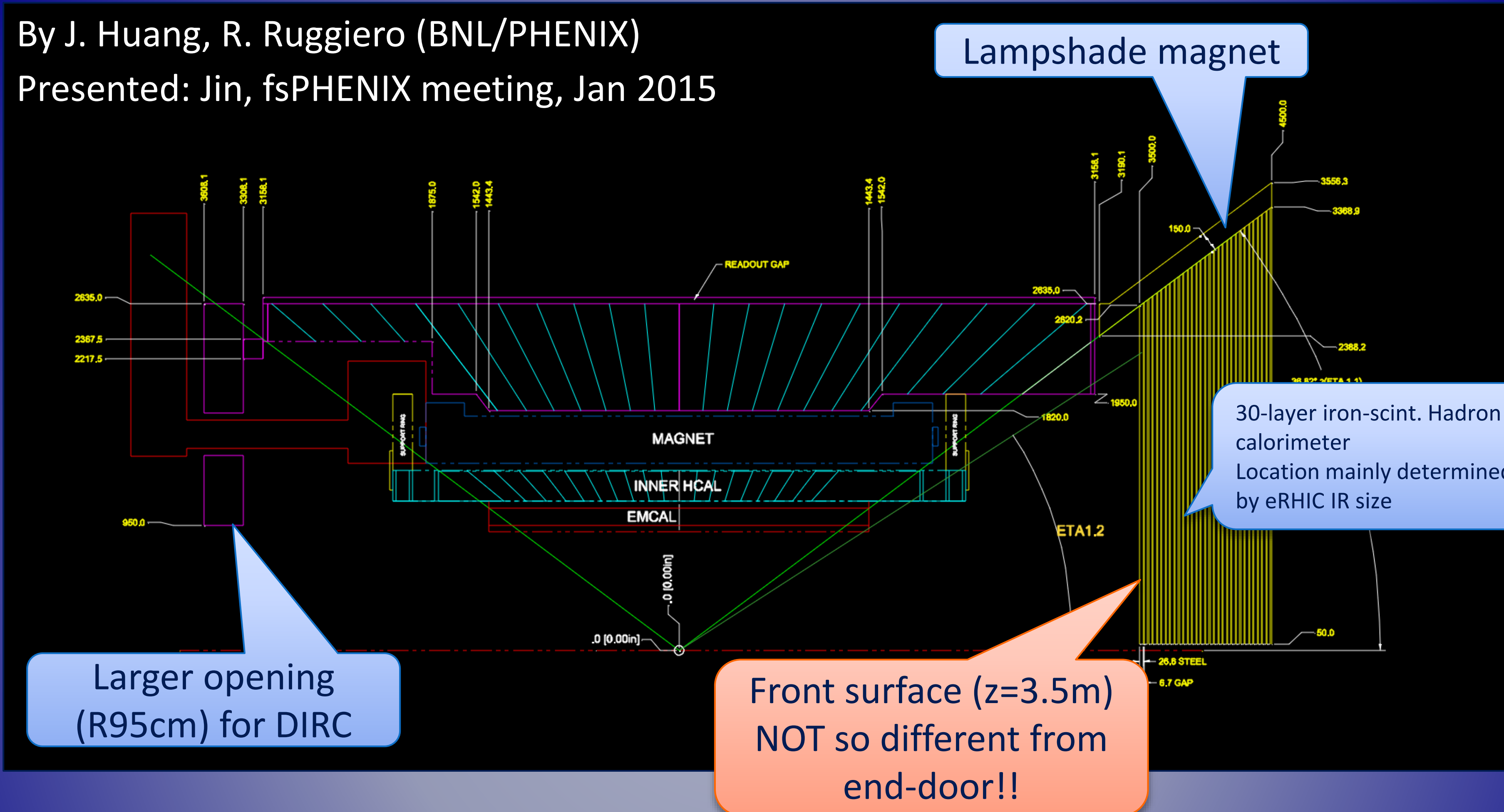
- BaBar superconducting magnet is a power full and large magnet
  - Nominal field: 1.5T
  - Length: 385 cm
- Field calculation and yoke tuning
  - Preliminary field calculation in 2D : POISSION, FEM, OPERA and COMSOL
- Favor for forward spectrometer
  - Designed for homogeneous B-field in central tracking
  - Longer field volume for forward tracking
    - FOM (Position resolution) ~ $B*L^2$
    - FOM (multiple scattering) ~ B*L
  - Higher current density at end of the magnet -> better forward bending
  - Work well with RICH with field-shaping yoke: Forward & central Hcal + Steel lampshade
- Shipped to BNL for sPHENIX

Field calculation in COMSOL (SBU)





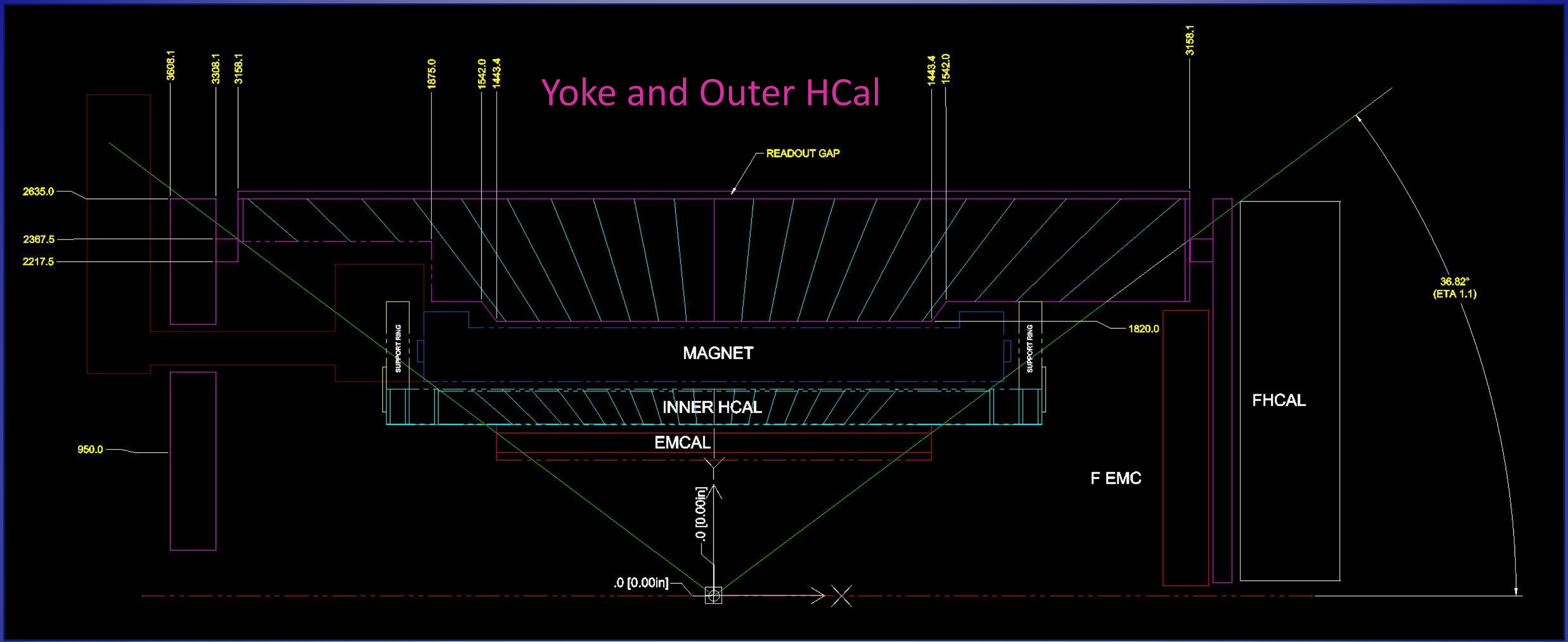
Current consideration



The past design

Steel/scintillator sampling hadron calorimeter

Coupling of forward calorimeter with sPHENIX field (budget, force, support)



Current design (only calorimeter is shown)

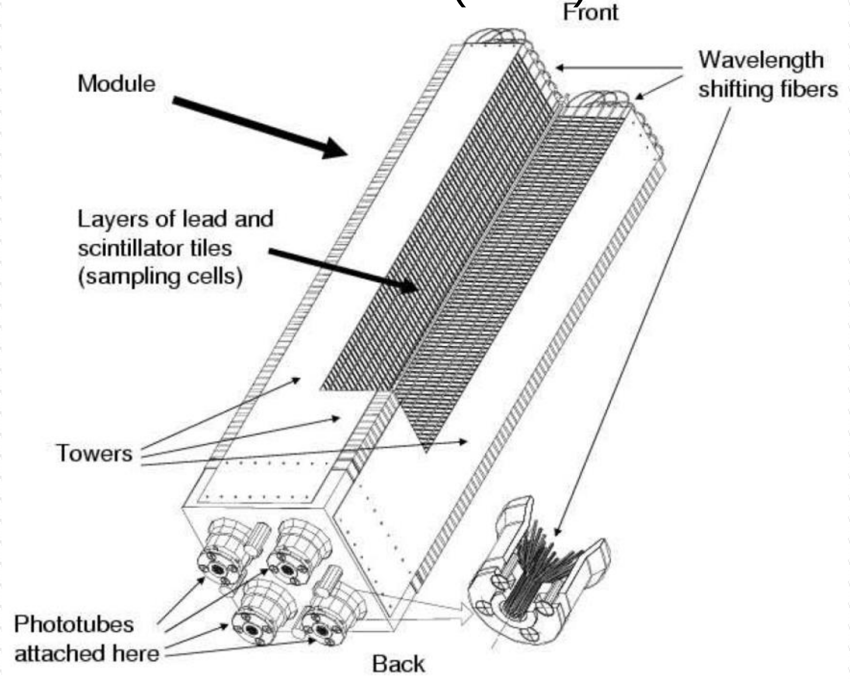
Restack of PHENIX EMCal

Keep magnetic end door ~ 1 interaction length, enough for field return

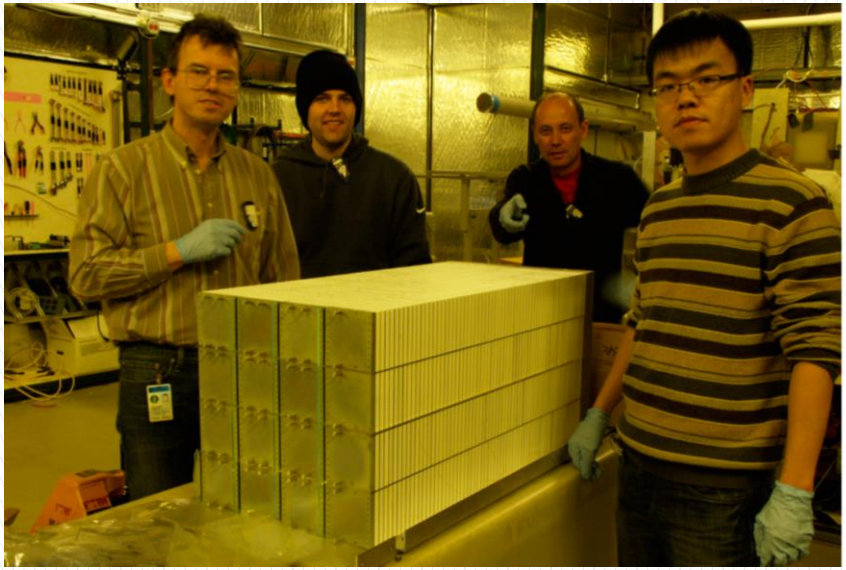
Stage-able HCal outside

Detector choice reference

NIM A499 521-536 (2003)



Courtesy: O. Tsai, A. Kiselev



EMCal concept

Reuse of PHENIX EMCal

Light guide -> SiPM for readout

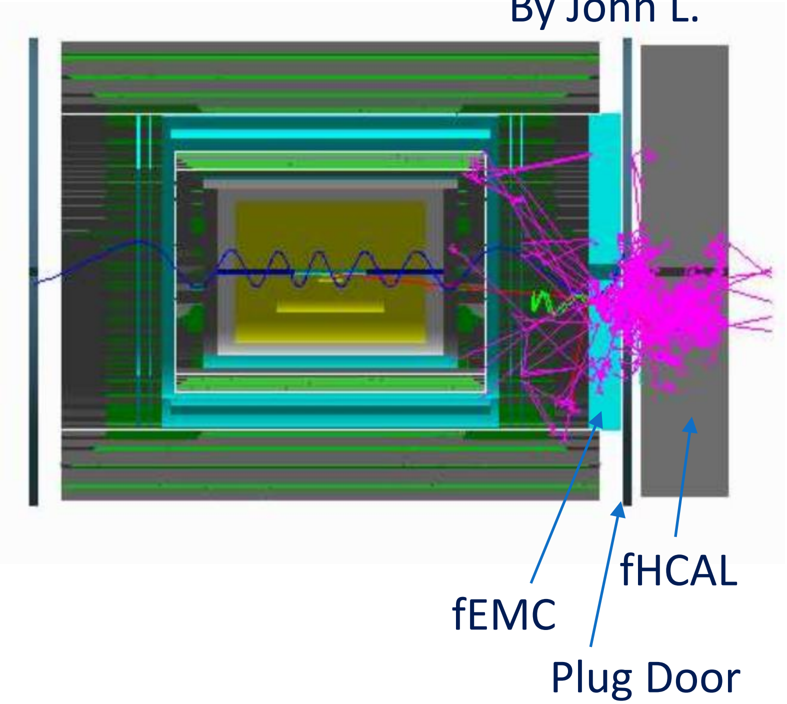
HCal concept

UCLA/BNL Pb/Scint sampling calorimeter

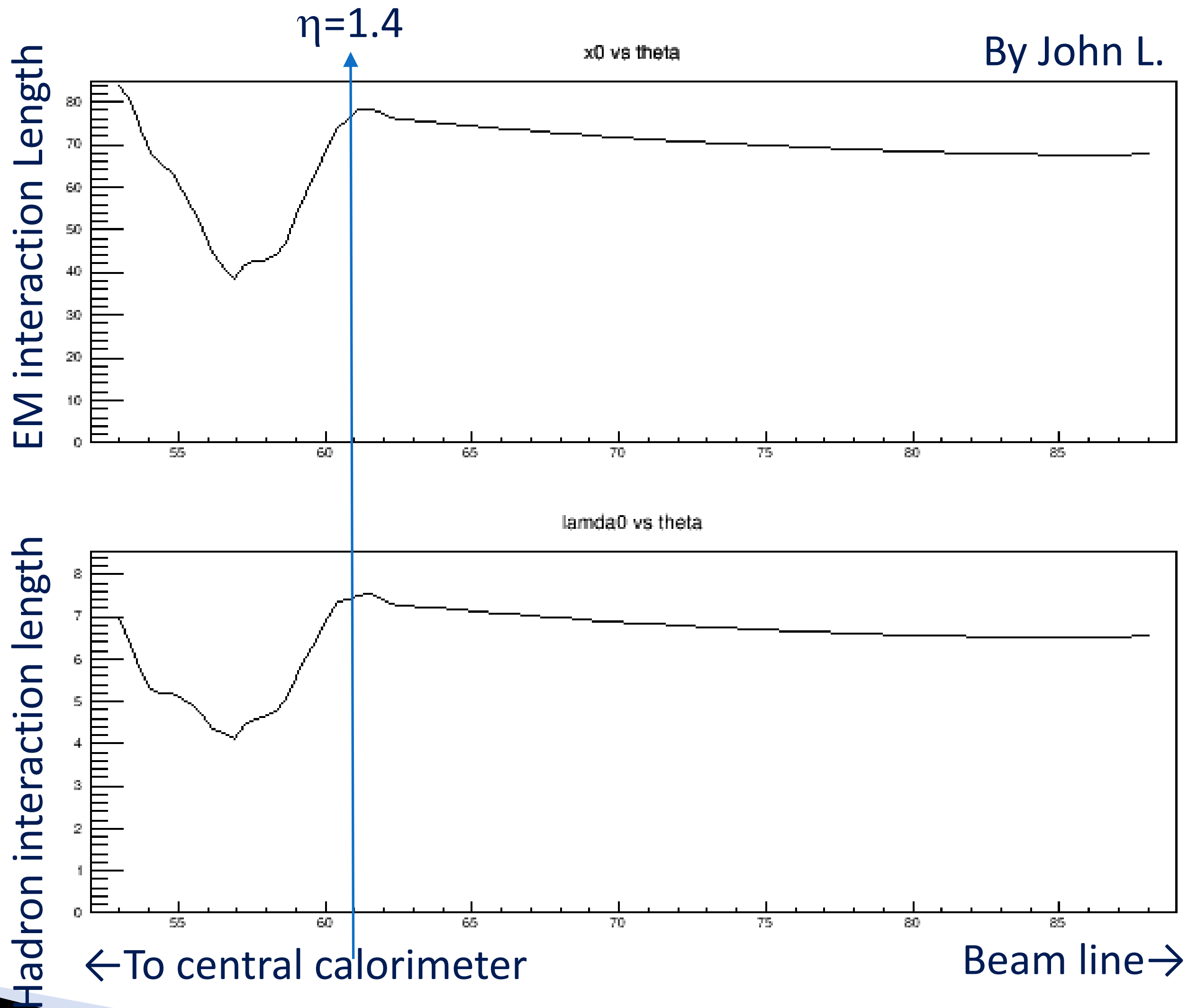
fsPHENIX Calorimeters in Geant4

- The FEMC is based on the PHENIX EMCal:
  - Tower size 5.535 cm x 5.535 cm
  - 36.3 cm in length
  - Lead and polystyrene scint.
  - Center at z = 310cm
  - Sampling fraction = 29.5%
- The FHCAL is based on the forward HCAL in the sPHENIX proposal:
  - 10 cm x 10 cm tower size
  - 100 cm in length
  - Steel and polystyrene scintillator in 4:1 ratio
  - Front face at z = 400cm.
  - Sampling fraction = 3.9%

By John L.



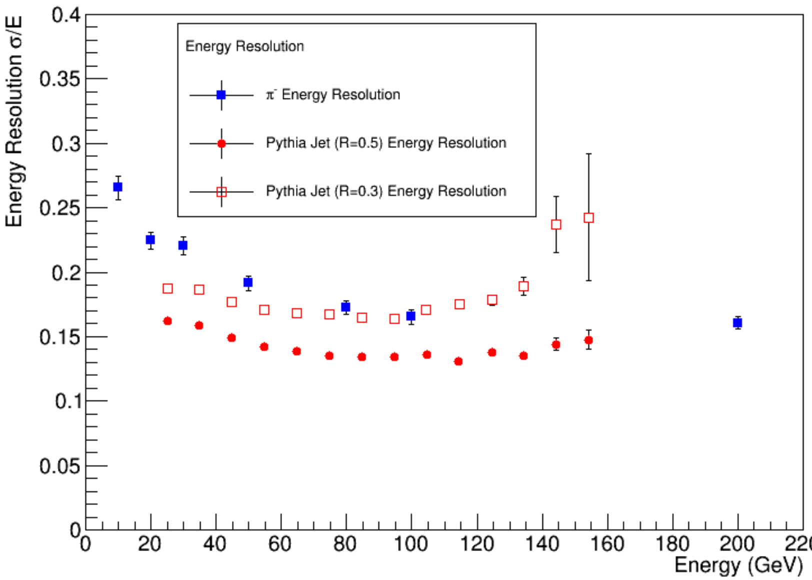
fsPHENIX Calorimeters in Geant4

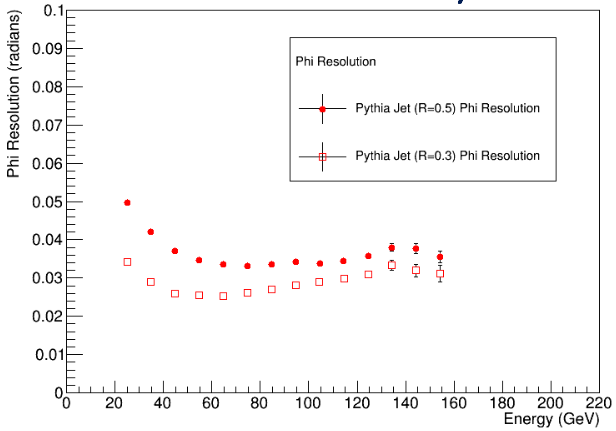


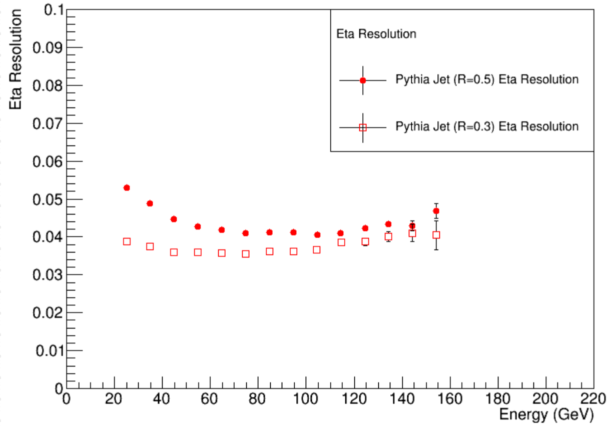
Jet performance in Geant4

By John L.

Magnet end door
-> 1 interaction length of inactive material
Limited to ~14% - large constant term



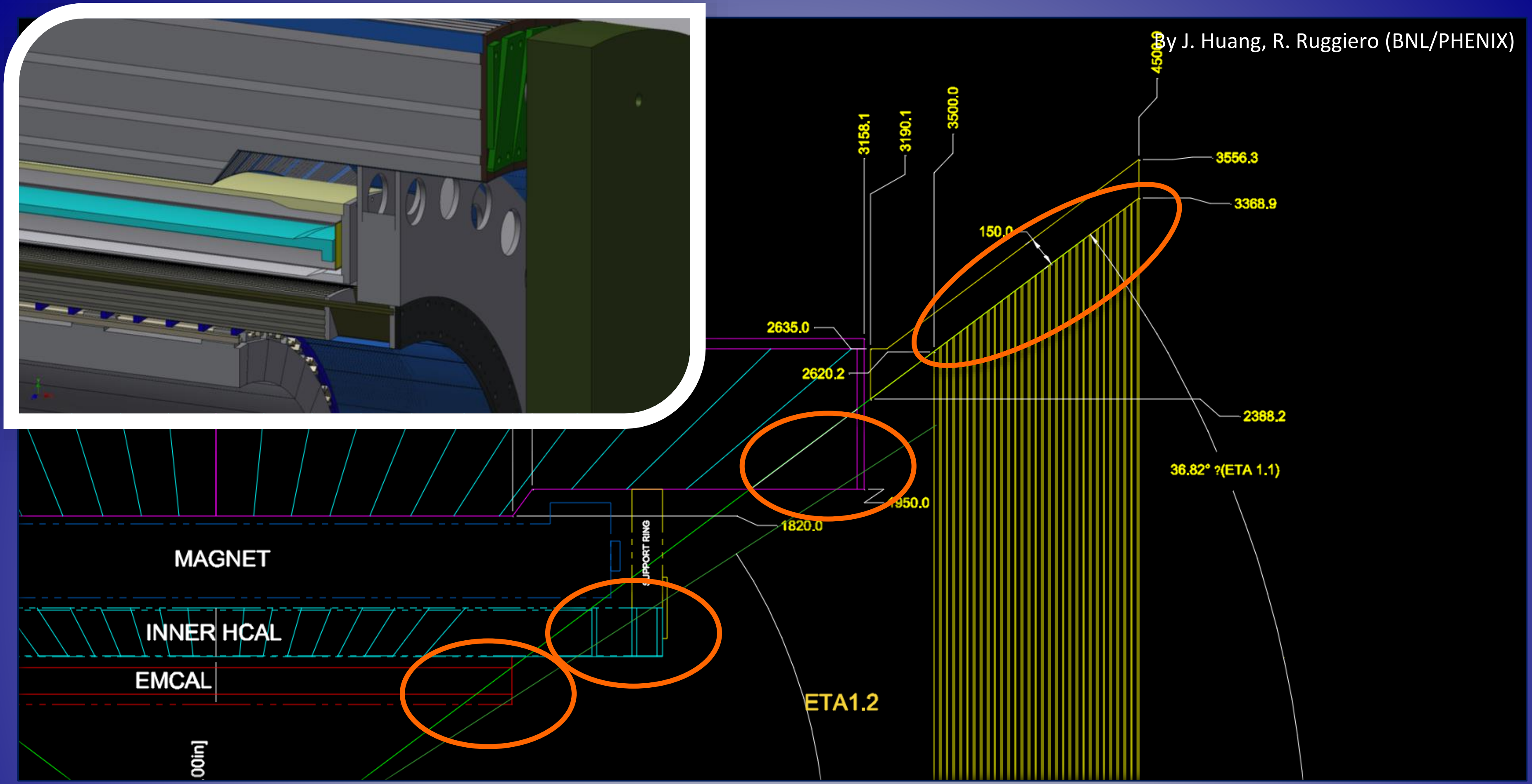




Energy resolution

Angular resolution

Connection to sPHENIX calorimetry



Would there be a jet coverage gap around η=1?

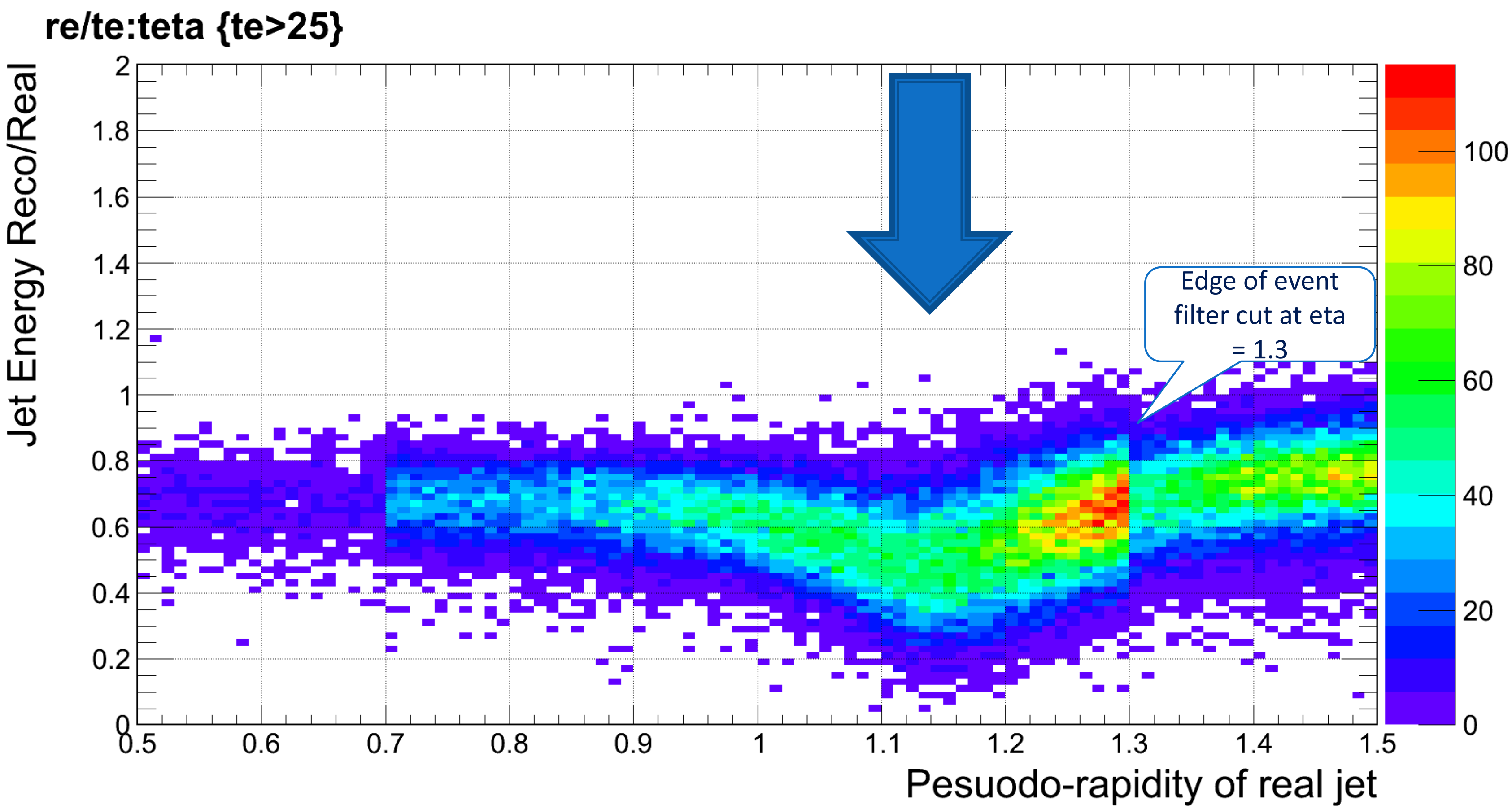
We were asked when presenting the design

My guess is gap is minimal by summing all four calorimeters

Finished Geant4 Jet production, close to quantify this effect

Geant4 Result from last generation of simulation:

- The missing central HCal piece produce a minor dip in jet energy response
- Require energy scale corrections
- Need revise for the new setups



Calorimetry Goals of this workfest

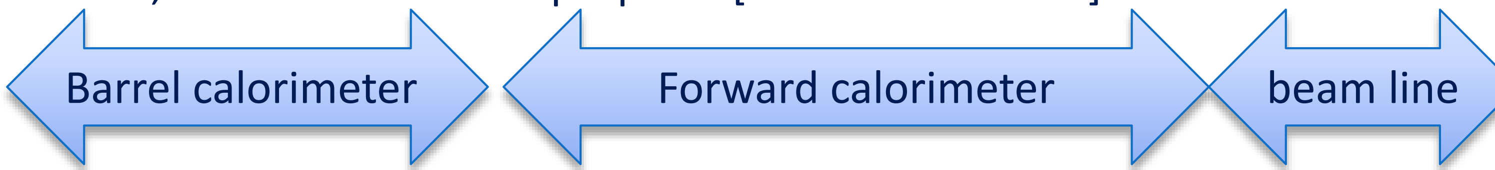
Calorimetry goals of this workfest

- New design
  - Look for comments from STAR/EIC colleagues and from external calorimeter experts
- Update the evaluation of jet performance
  - Simulation tutorial tomorrow. Help needed (Thanks Chong!)
  - Nils and I are putting together the update to ePHENIX sim
- Performance under pA background embedding (in full Geant4)
- Di-jet in ep, eA (in full Geant4)
  - Handle of background
  - Detector resolution to q_T smearing

2.5m Hcal summary
– need refresh for new calo, should do better

2.5m FHCal results

Presented: Appendix A, Nov-2014 sPHENIX proposal [arXiv:1501.06197]



- R=0.6 is better for energy resolution
- R=0.4 is better for angular measurement and for pA
- Matching energy resolution in barrel for pp
- Good angular resolution
- Some complexity for
  - Energy matching barrel-forward join region
  - Angular resolution for very forward region